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ABSTRACT

The meta-analytic approach used in this review is similar to that described by Glass et al. (1981), whose approach requires a reviewer to locate and code studies of an issue, to code study outcomes on a common scale, and to use statistical methods to relate study features to outcomes. The studies considered for use in this meta-analysis came from three sources: references in Orlansky and String's (1979) review of findings on computer effectiveness in military training; a computer search of two data bases, Comprehensive Dissertation Abstracts and ERIC; and branching from the bibliographies in documents located through these computer searches. The procedure yielded 24 studies that met basic criteria for inclusion in the study pool. The instructional outcome measured most often was student learning, as indicated on achievement examinations given at the end of the program of instruction. Findings indicate that computer based education (CBE) usually has positive effects on the adult learner: CBE raised the examination scores of such students by 0.42 standard deviations in the average study. Two study features appeared to be related to the size of achievement effect reported in the studies: type of CBE and publication source for the studies. However, reliable conclusions cannot be reached about long-term cognitive effects of CBE because of the small number of studies in this area. (Author/JB)

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Effectiveness of Computer-Based Adult Education

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Abstract

A meta-analysis of findings from 24 controlled evaluations showed that computer-based education (CBE) usually has positive effects on adult learners. CBE raised the examination scores of such students by 0.42 standard deviations in the average study--a moderate-size but statistically significant effect. Two study features appeared to be related to the size of achievement effect reported in the studies: type of use of CBE and publication source for the studies. CBE also reduced substantially the amount of time needed for instruction. Reliable conclusions could not be reached about affective or long-term cognitive effects of CBE because of the small number of studies in these areas.

Effectiveness of Computer-Based Adult Education

When people think of computer-based education (CBE), they ordinarily think of elementary schools, high schools, and colleges. Such schools have played an important part in forming conceptions of what CBE is and what it can do. But developments in traditional schools are only a part of the story of CBE. Some of the most important developments in CBE have taken place with adult learners in nontraditional settings.

The first systems of CBE were in fact developed not for conventional schools but for training personnel at computer companies (Hall, 1982). The first instructional programs covered such nontraditional subjects as stenotype and binary arithmetic. In the years since the development of these first programs, training of adults has been a major focus in CBE development. CBE applications in the Air Force, Army, and Navy have often been on the cutting edge of developments. And private corporations have spent millions of dollars on the development of courseware for nontraditional adult learners. A major recent effort of the Control Data Corporation, for example, has been the development of a basic skills curriculum in mathematics, reading, and language designed to prepare non-high school graduates to take the general educational development (GED) tests and earn a high school diploma equivalency certificate.

Evaluators have conducted numerous outcome studies over the years to measure the effects of CBE on adult learners. These outcome studies use an experimental design that is often employed in studies with traditional learners. In a typical outcome study, a researcher divides a class of students into an experimental and a control group. Members of the experimental group receive part of their instruction at computer terminals, whereas members of the control group receive their instruction by conventional methods. At the end of the study, the researcher compares responses of the two groups on a common examination or on a course evaluation form.

No individual outcome study, however, can show whether CBE is generally effective with adult learners. CBE can no more be evaluated by a single outcome study than all textbooks, lectures, or films can be judged on the basis of a single comparison. To draw general conclusions, it is necessary to take into account the results from a variety of outcome studies carried out in a variety of settings under

different circumstances. Formal tools of research synthesis must be applied to the results of the individual outcome studies.

Research syntheses are often classified into two major types: box score tabulations and meta-analyses. Box score reviews usually report the proportion of studies favorable and unfavorable to an experimental treatment, and they often provide narrative comments about the studies as well. Reviewers using meta-analysis take a more quantitative approach to their task (Glass, McGaw, & Smith, 1981). They use (a) objective procedures to locate studies; (b) quantitative or quasi-quantitative techniques to describe study features and outcomes; and (c) statistical methods to summarize overall findings and explore relationships between study features and outcomes.

Numerous reviewers have used these two methods to draw conclusions about the effectiveness of CBE with traditional learners. Reviews on CBE effectiveness with nontraditional adult learners are much harder to find. Our extensive search of the literature yielded only Orlansky and String's (1979) review on effectiveness of CBE in military training. Their review covered 48 evaluation studies described in 30 separate documents. Orlansky and String classified (a) 32 of the 48 studies as showing no difference in achievement of trainees in CBE classrooms and conventional classrooms; (b) 15 of the 48 studies as showing CBE to be superior to conventional teaching in improving student learning; and (c) 1 of the 48 studies as showing CBE to be inferior to conventional teaching. On the basis of these box score results, Orlansky and String concluded that the difference in achievement between students in CBE and conventional classrooms had no practical significance. Orlansky and String concluded, on the other hand, that CBE had an important effect on instructional time because the studies also showed a saving of 30% in instructional time in CBE classrooms.

Our review differs from Orlansky and String's review in at least two major respects. First, it covers a broader range of studies. Our review examines studies in both military and nonmilitary settings, and it examines effects of CBE in technical training and in adult basic education. Second, our review uses a meta-analytic methodology. This approach is generally considered to be superior to box-score methodology because it uses more of the information included in the original reports.

This review is meant to answer questions such as these: How effective is CBE with adult learners in nontraditional settings? Is it especially effective for certain types of outcomes? Are certain types of programs especially effective, or is CBE especially effective with certain types

of adult learners? Under which conditions does CBE appear to be most effective with adults?

Method

The meta-analytic approach used in this review is similar to that described by Glass et al. (1981). Their approach requires a reviewer (a) to locate studies of an issue through objective and replicable searches; (b) to code the studies for salient features; (c) to code study outcomes on a common scale; and (d) to use statistical methods to relate study features to outcomes.

Data Sources

The studies considered for use in this meta-analysis came from three major sources. One group of studies came from the references in Orlansky and String's (1979) review of findings on computer applications in military training. A second group of studies was located by computer-searching two library data bases using Lockheed's Dialog Online Information Services. The data bases searched in this way were (a) Comprehensive Dissertation Abstracts; and (b) ERIC, a database on educational materials from the Educational Resources Information Center, consisting of the two files Research in Education and Current Index to Journals in Education. A third group of studies was retrieved by branching from bibliographies in the documents located through these computer searches.

These search procedures yielded 24 studies that met four basic criteria for inclusion in our study pool. First, the studies had to take place in actual classrooms. They had to involve real teaching, not an analog of teaching. Second, the studies had to provide quantitative results on outcome variables measured in the same way in both a computer-taught and a conventionally instructed class. Uncontrolled "experiments" and anecdotal reports were not acceptable. Third, the studies had to be free from such crippling methodological flaws as substantial differences in aptitude of treatment and control groups, unfair "teaching" of the criterion test to one of the comparison groups, and differential rates of subject attrition from the groups being compared. And fourth, the studies had to be retrievable from university or college libraries by interlibrary loan or from the Educational Resources Information Center, the National Technical Information Service, or University Microfilms International.

These standards kept us from using all the reports cited by Orlansky and String (1979). We were not able to retrieve 8 of the 30 reports used in their review, including 5 evaluation reports from the Technical Training Center at

Keesler Air Force Base in Mississippi. In addition, we eliminated 5 studies cited by Orlansky and String because the studies appeared to us to be methodologically flawed. The remaining 17 reports cited by Orlansky and Strong were treated as 10 independent studies in our meta-analysis.

Outcome Measures

The instructional outcome measured most often in the 24 studies was student learning, as indicated on achievement examinations given at the end of the program of instruction. The next most frequently measured outcome variable, examined in 13 studies, was amount of time needed for instruction. Other outcome variables measured in the studies were the following: (a) performance on a follow-up or retention examination given some time after the completion of the program of instruction; (b) attitude toward computers; (c) attitude toward instruction; (d) attitude toward school subjects; and (e) course completion.

For statistical analysis, outcomes had to be expressed on a common scale of measurement. The transformation used for this purpose was the one recommended by Glass et al. (1981). Like Glass and his colleagues, we coded each outcome as an Effect Size (ES), defined as the difference between the mean scores of two groups divided by the standard deviation of the control group. For studies that reported means and standard deviations for both experimental and control groups, ES could be calculated directly from the measurements provided. For less fully reported studies, ES could usually be calculated from statistics such as t and F.

The application of the formulas given by Glass and his colleagues was straightforward in most cases. In some studies, however, more than one value was available for use in the numerator of the formula for ES and more than one value was available for the denominator. For example, some investigators reported raw-score differences between groups as well as covariance-adjusted differences, and some reported differences on a post-measure as well as differences in pre-post gains. In such cases, we used as the numerator of ES the difference that was least likely to be affected by individual differences among subjects and by other irrelevant factors. This meant using covariance-adjusted differences rather than raw-score differences, and differences in gains rather than differences on posttests. In addition, some reports contained several measures of variation that might be considered for use as the denominator of ES. We use the measure that provided the best estimate of the unrestricted population variation in the criterion variable.

For measurement of the size of CBE effects on course completion, we used the statistic h (Cohen, 1977). This

statistic is appropriate for use when proportions are being compared. It is defined as the difference between the arcsine transformation of proportions associated with the experimental and control groups. To code CBE effects on instructional time, we used a ratio of two measurements: the instructional time required by the experimental group divided by the instructional time required by the control group.

Study Features

A total of 16 variables were used to describe treatments, methodologies, settings, and publication histories of the studies (Table 1). These 16 variables were chosen on the basis of (a) an examination of variables used to describe study features in previous reviews, and (b) a preliminary examination of dimensions of variations in the studies located for this analysis. Two coders independently coded each of the studies on each of the variables. The coders then jointly reviewed their coding forms and discussed any disagreements. They resolved these disagreements by jointly reexamining the studies whose coding was in dispute.

Insert Table 1 about here

Unit of Statistical Analysis

Some studies reported more than one finding for a given outcome area. Some of these multiple findings resulted from the use of more than one experimental or control group in a single study. Others resulted from the use of several subscales and subgroups to measure a single outcome. Using several ESs to represent results from one outcome area of one study seems to be inappropriate to us. Such multiple ESs are nonindependent; they often come from a single group of subjects or from overlapping subject groups, and they almost always represent the effects of a single program implemented in a single setting. To represent a single outcome by several ESs violates the assumption of independence necessary for many statistical tests and also gives undue weight to studies with multiple groups and multiple scales.

The procedure that we adopted, therefore, was to calculate only one ES for each outcome area of each study. A single rule helped us to decide which ES best represented the study's findings. The rule was to use the ES from what would ordinarily be considered the most methodologically sound comparison when comparisons differed in methodological adequacy. (a) When results from both a true experimental comparison and a quasi-experiment were available from the

same study, results of the true experiment were recorded. (b) When results from a long and short CBE implementation were available, results from the longer implementation were used. (c) When transfer effects of CBE were measured in addition to effects in the area of instruction, the direct effects were coded for the analysis. (d) In all other cases, our procedure was to use total score and total group results rather than subscore and subgroup results in calculating ES.

Results

Because most of the studies in the pool investigated effects of CBE on examination performance, we were able to carry out a complete statistical analysis of results in this area. The analysis covered both average effects and the relationship between effects and study features. We carried out less complete statistical analyses of other outcome areas because of the limited number of studies available in these areas.

Examination Performance

A total of 23 of the 24 studies in our pool reported results from CBE and control groups on an examination given at the end of instruction (Table 2). In 19 of the 23 studies, the CBE class had the higher examination average; in 4 studies, the conventionally taught class had the higher average. The difference in examination performance of CBE and control students was reported to be significant in 11 studies. In 10 of the 11 cases, the significant difference favored the CBE class, whereas only 1 study favored conventional teaching. Overall, these box-score results favor CBE.

Insert Table 2 about here

The index ES provides a more exact picture of the degree of benefit from CBE in the typical study. The average ES in the 23 studies was 0.42; its standard error was 0.11. This average ES means that in the typical study, the average score for the CBE group was 0.42 standard deviations higher than the average score for the control group. ESs can also be expressed in terms of percentile scores. Approximately 66% of the area of the standard normal curve falls below a z-score of 0.42. We can conclude, therefore, that the typical student in an average CBE class would perform at the 66th percentile on an achievement examination, whereas the typical student in a conventionally taught class would perform at the 50th percentile on the same examination. Put in another way, the

average student from the CBE class would outperform 66% of the students from a conventional class.

Examination Performance and Study Features

Although the increase in examination performance attributable to the computer was moderate in the typical study, effects varied in magnitude from study to study. The strongest positive result reported was an effect of 1.53 standard deviations (Attia, Miller, & Kitz, 1975); the strongest negative result was an effect of -0.68 standard deviations (Schwartz & Long, 1967). It seemed possible that this variation in study outcome might be systematic, and further analyses were conducted therefore to determine whether different types of studies were in fact producing different results.

Insert Table 3 about here

Although none of the study features proved to be significantly related to achievement ES, two features were related to study outcome at a borderline level of significance (Table 3). First, average ES tended to vary with type of use of the computer in instruction, $F(2,20) = 3.42$, $p = .053$. Average ES was highest in the 2 studies that examined effects of CEI programs ($M = 1.13$); it was next highest in the 3 studies of CMI programs ($M = 0.72$); and it was lowest in the 18 studies of CAI programs ($M = 0.29$). Second, ES tended to vary with publication source, $F(1,21) = 3.37$, $p = .081$. Average ES was higher in published studies ($M = 0.69$) than it was in unpublished ones ($M = 0.28$).

Instructional Time

Thirteen studies compared the instructional time for students in the CBE and conventional classrooms. In the average study, the ratio of amount of instructional time for CBE students to amount of instructional time for students studying conventionally was .71. In other words, CBE students required less than three-fourths as much instructional time as did students who were taught conventionally. The range of ratios varied from .16 to 1.14. In only one case did the conventionally taught class require more instructional time than the CBE class (General Electric Ordnance System, 1975).

Insert Table 4 about here

Other Effects

Only a few studies evaluated CBE using effectiveness criteria other than student learning and instructional time.

Retention at follow-up. Three studies examined effects of CBE on a test given some time after the completion of instruction. Carson, Graham, Harding, Johnson, Mayo, and Salop (1975) reported that retention-test scores of CBE students were 0.45 standard deviations higher than scores of a control group after a retention interval of six weeks. Longo (1976) compared test scores of CBE and conventional learners after an interval of two weeks and found the average of the CBE group to be 0.19 standard deviations higher than the average of the control group. Stern's (1975) comparison yielded an ES of 0.17 after a retention interval of six weeks. It is important to note that in each of these studies, the CBE group had higher scores on the retention test.

Student attitudes. Two studies examined the effects of CBE on student attitudes toward instruction, and both of the studies reported a near-zero effect of CBE (Carson et al., 1975; Schwartz & Haskell, 1966). Two studies examined effects of CBE on student attitudes toward the subject matter that they were being taught. One of these studies reported a large effect, and yielded an ES of 0.96 (Dallman, DeLeo, Main, & Giliman, 1977); the other yielded a small ES of 0.18 (Scanland, 1970). Finally, a study conducted by Demidovich (1975) reported that students taught by CBE developed more favorable attitudes toward the computer than did students taught conventionally. Attitude scores of the CBE group were 0.34 standard deviations higher than the scores of the control group.

Course Completion. Two studies compared completion rates in courses taught conventionally and with CBE. In Geller and Shugoll's (1983) study, the average dropout rate was 55% for the CBE group vs. 68% for the conventionally taught group, yielding an h of 0.27. In Longo's (1976) study, the difference in percentage of dropouts from CBE and conventional groups was smaller. The dropout rate was 15% for the CBE group and 14% for the conventional group, yielding an h of -0.03.

Discussion

This meta-analysis showed that CBE has basically positive effects on adult learners. It raised final examination scores in the typical study by 0.42 standard deviations, or from the 50th to the 66th percentile. This figure is identical to the average effect size of 0.42 reported in our earlier meta-analysis of findings on achievement at the elementary level (J. Kulik, Kulik, &

Bangert-Drowns, in press), but it is higher than the average effect size of 0.26 in our meta-analyses of high school and college findings (Bangert-Drowns, Kulik, & Kulik, in press; C. Kulik & Kulik, 1985).

The analysis did not produce conclusive evidence of a relationship between study features and achievement outcomes of CBE studies. Design features of experiments, for example, did not influence outcomes. Quasi-experimental studies and true experiments produced similar results. Experiments with controls for historical effects yielded the same results as experiments without historical controls. Studies in which the control group was taught by the lecture method produced the same results as studies in which the control group was taught by an individualized method. CBE was also equally effective in basic skills education and in technical training.

The size of achievement effect showed a tendency, however, to be related to the type of CBE used in the studies. Evaluations of CAI yielded an average ES of 0.29, whereas studies of CMI yielded an average ES of 0.72 and studies of CEI yielded an average ES of 1.13. The difference among effects reached only a borderline level of statistical significance. One factor that might explain the lack of clear findings in this area was the small number of studies of CMI and CEI. Eighteen of the 23 studies with achievement data investigated CAI effects, whereas only 3 studies examined CMI programs and 2 studies examined CEI effects. More studies of CMI and CEI are needed for firmer conclusions.

Even with the limited number of studies available, it seems clear that CAI effects do not vary as much with instructional level as CMI and CEI effects do (J. Kulik, Kulik, & Bangert-Drowns,in press; Bangert-Drowns, Kulik & Kulik, in press; C. Kulik & Kulik, 1985). The average ES in CAI studies was 0.47 at the elementary level, 0.36 at the secondary level, 0.26 at the college level, and 0.29 at the adult level. In contrast, average CMI effects were 0.07 at the elementary level, 0.40 at the secondary level, 0.35 at the college level, and 0.72 at the adult level. Average effects of CEI were even more variable: 0.07 at the secondary level, 0.23 at the college level, and 1.13 at the adult level. One implication is that currently available CAI systems can make a positive contribution at all instructional levels, whereas effectiveness has not been established for CMI and CEI in elementary schools and for CEI in secondary schools.

Publication source of a study was also related to study outcome at a borderline level of statistical significance. Results found in journal articles were more positive than were results from dissertations and technical documents.

The difference in effects from these different sources was highly predictable. A difference between journal and dissertation results has been reported in numerous quantitative syntheses of research and evaluation findings (Bangert-Drowns et al., 1984; Glass et al., 1981, pp. 64-68). The relationship is one of the best documented findings in the meta-analytic literature.

The factors that produce this difference, however, are not completely understood. Some writers have attributed the difference in journal and dissertation findings to publication bias (e.g., Clark, in press). This is the purported tendency of researchers, reviewers, and editors to screen reports for publication on the basis of size and statistical significance of effects, rather than on the basis of study quality. Such publication bias would make journals an unreliable source for information about the effectiveness of experimental treatments. Other writers have noted that journal studies and other studies are carried out by different persons working under different conditions (e.g., J. Kulik, Kulik, & Bangert-Drowns, in press). The typical author of a journal article, for example, differs from the typical dissertation writer in research experience, resources, professional status, and many other respects. If the weakness of dissertation results is due to the inexperience of dissertation writers, then dissertations are a poor source for information on the effectiveness of treatments.

One of the more dramatic findings in this meta-analysis was the reduction in instructional time associated with CBE. In 12 of the 13 studies reporting instructional time, the computer did its job quickly--on the average in about 71% of the time required by conventional teaching methods. This saving in instructional time is nearly identical to the amount of time-saving (30%) reported in Orlansky and String's (1979) review. It is also very similar to the amount of time-saving with CBE found in a recent analysis of college-level CBE (C. Kulik & Kulik, 1985). It is clear therefore that the computer can function satisfactorily in adult education and at the same time reduce time spent in instruction.

Very few studies provided results on the effectiveness of adult CBE in other outcome areas. It is interesting to note, however, that the results reported on attitudinal effects, attrition, and retention were basically positive. Future evaluations of effects of adult CBE should pay more attention to effects in such areas. CBE shows enough promise in adult education for evaluators to examine more closely its broad, long-term cognitive and its affective outcomes, as well as its immediate effects on learning and instructional time.

References

Aaron, R. L., Call, L. T., & Muench, S. (1975). A language arts program for disturbed adolescents. Journal of Reading, 19, 208-213.

Attia, R. R., Miller, E. V., & Kitz, R. J. (1975). Teaching effectiveness: Evaluation of computer-assisted instruction for cardiopulmonary resuscitation. Anesthesia and Analgesia, 54, 308-311.

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C.-L. C. (1984, August). The influence of study features on outcomes of educational research. Paper presented at the meeting of the American Psychological Association, Toronto.

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C.-L. C. (in press). Effectiveness of computer-based education in secondary schools. Journal of Computer-Based Instruction.

Buckley, E., & Rauch, D. (1979). Pilot project in computer assisted instruction for adult basic education students. Great Neck, NY: Great Neck Public Schools. (ERIC Document Reproduction Service No. ED 197 202)

Carson, S. B., Graham, L. L., Harding, L. G., Johnson, K. A., Mayo, G. D., & Salop, P. A. (1975). An evaluation of computer-managed instruction in Navy technical training (NPRDC Report No. TR 75-38). San Diego, CA: Navy Personnel Research and Development Center. (NTIS No. AD-A012 638)

Clark, R. E. (in press). Confounding in educational computing research. Journal of Educational Computing Research.

Cohen, J. (1977). Statistical power analysis for the behavioral sciences (Rev. ed.). New York: Academic Press.

Crawford, A. M., & Crawford, K. S. (1978). Simulation of operational equipment with a computer-based instructional system: A low cost training technology. Human Factors, 20, 215-224.

Dallman, B. E., DeLeo, P. J., Main, P. S., & Giliman, D. C. (1977). Evaluation of PLATO IV in vehicle maintenance training (Report No. AFHRL-TR-77-59). Lowry AFB, CO: Air Force Human Resources Laboratory. (ERIC Document Reproduction Service No. ED 153 638)

Deignan, G. M., & Duncan, R. E. (1978). CAI in three medical training courses: It was effective! Behavior Research Methods and Instrumentation, 10, 228-230.

Demidovich, J. W. (1975). The influence of a computer assisted instruction experience upon the attitudes of logisticians in the Department of Defense. Dissertation Abstracts International, 36, 7128A. (University Microfilms No. 76-9955)

Evans, R. M., Skiles, S. C., & Harris, J. C. (1979, November). The Marine Corps mastery learning project: Effect of self-paced course reorganization on learning time and achievement. Paper presented at the meeting of the Association for the Development of Computer-based Instructional Systems, Washington, DC.

Fairweather, P. G., & Diem, R. A. (1978). Computer-assisted education in a county jail: An overview of a pilot project. Offender Rehabilitation, 3, 151-159.

Ford, J. D., Jr., Slough, D. A., & Hurlock, R. E. (1972). Computer assisted instruction in Navy technical training using a small dedicated computer system: Final report (NPTRL Report No. SRR 73-13). San Diego, CA: Navy Personnel and Training Research Laboratory. (NTIS No. AD-752 999)

Fredericks, P. S., & Hoover-Rice, L. B. (1977). Computer-based training of recipe conversion with lower aptitude personnel (NPRDC Report No. TR 77-24). San Diego, CA: Navy Personnel Research and Development Center. (NTIS No. ADA 038-420)

Geller, D. M., & Shugoll, M. (1983). The impact of computer-assisted instruction on disadvantaged young adults in a non-traditional educational environment. Reston, VA: Advanced Technology. (ERIC Document Reproduction Service No. ED 229 501)

General Electric Ordnance Systems. (1975). Computer based instruction evaluation project: Final report. Vol. 1. Conduct and results of the computer based instruction evaluation (Contract No. 0003074C0169). Pittsfield, MA: Author.

Glass, G. V, McGaw, B., & Smith, M. L. (1981). Meta-analysis in social research. Beverly Hills, CA: Sage Publications.

Hall, K. A. (1982). Computer based education. In H. E. Mitzel (Ed.), Encyclopedia of educational research (pp. 353-363). New York: The Free Press.

Hirata, E. T. (1973). An experimental study to determine the effectiveness of computer-assisted instruction in paired learning. Dissertation Abstracts International, 34, 1000. (University Microfilms No. 73-20,435)

Kulik, C.-L. C., & Kulik, J. A. (1985). Effects of computer-based education in colleges. Ann Arbor, MI: University of Michigan, Center for Research on Learning and Teaching.

Kulik, J. A., Kulik, C.-L. C., & Bangert-Drowns, R. L. (in press). Effects of computer-based education on elementary school pupils. Computers and Human Behavior.

Longo, A. A. (1976). Guidelines for optimum utilization of computerized training systems as based on an analysis and evaluation of such programs in the U.S. Army. Ft. Lauderdale, FL: Nova University. (ERIC Document Reproduction Service No. ED 129 312)

Longo, A. A., & Giunti, F. E. (1972). A sequential evaluation of computer assisted instruction in US Army basic electronics training. Fort Monmouth, NJ: Army Signal Center and School. (ERIC Document Reproduction Service No. ED 011 433)

Meyer, L. A., Ory, J. C., & Hinckley, R. C. (1983). Evaluation research in basic skills with incarcerated adults. Urbana, IL: University of Illinois. (ERIC Document Reproduction Service No. ED 227 280)

Orlansky, J., & String, J. (1979). Cost-effectiveness of computer-based instruction in military training (IDA paper P-1375). Arlington, VA: Institute for Defense Analysis, Science and Technology Division.

Ozarowksi, P. C., Jr. (1973). A study in the design and implementation of a course in the basic fundamentals of statistics via a computer. Dissertation Abstracts International, 34, 2310. (University Microfilms No. 73-27,317)

Scanland, F. W. (1970). An investigation of the relative effectiveness of two methods of computer-assisted instruction as techniques for changing the parental attitudes of Negro adults (Report No. TR-13). Washington, DC: Office of Naval Research. (ERIC Document Reproduction Service No. ED 043 224)

Schwartz, H. A., & Haskell, R. J., Jr. (1966). A study of CAI in industrial training. Journal of Applied Psychology, 50, 360-363.

Schwartz, H. A., & Long, H. S. (1967). A study of remote industrial training via computer-assisted instruction. Journal of Applied Psychology, 51, 11-16.

Stern, H. W. (1975). Transfer of training following computer-based instruction in basic oscilloscope procedures (NPRDC Report No. TR 76-1). San Diego, CA: Navy Personnel Research and Development Center. (NTIS No. AD-A012 637)

Trollip, S. R. (1979). The evaluation of a complex computer-based flight procedures trainer. Human Factors, 21, 47-54.

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Table 1

Categories Used to Describe Study Features

Computer Use

Type of application

Computer-assisted instruction (CAI) -- The computer provides (a) drill-and-practice exercises but not new materials, or (b) tutorial instruction that includes new material.

Computer-managed instruction (CMI) -- The computer evaluates student test performance, guides students to appropriate instructional resources, and keeps records of student progress.

Computer-enriched instruction (CEI) -- The computer (a) serves as a problem-solving tool, (b) generates data at the student's request to illustrate relationships in models of social or physical reality, or (c) executes programs developed by the student.

Duration of instruction

More than 9 weeks

Less than 9 weeks

Author of program

Local -- Computer materials were developed locally for a specific setting.

Other -- Computer materials were developed for use in a wide variety of settings.

Type of computer interaction

Off-line

Terminal with mainframe

Microcomputer

Methodology

Subject assignment

Random -- Subjects were randomly assigned to the experimental and control groups.

Nonrandom -- A quasi-experimental design was used.

Control for instructor effects

Same instructor -- The same teacher or teachers taught both the experimental and control groups.

Different instructors -- Different teachers taught the two groups.

Control for historical effect

Same semester -- Subjects in experimental and control groups were taught concurrently.

Different semesters -- Two groups were not taught concurrently.

Instructional method for control group

Lecture method

Individualized instruction -- Instructional methods used tutoring, self-paced method, or individualized workbooks.

Control for test-author bias

Commercial -- A standardized test was used as the criterion measure for student achievement.

Local -- A locally developed tests was used as the criterion measure.

Control for bias in test scoring

Objective -- Objective, machine-scorable examinations were used to measure student achievement, e.g., multiple-choice tests.

Nonobjective -- Subjective decisions had to be made in scoring tests, e.g., essay tests.

Control for evaluator involvement

Involved -- The evaluator was involved in developing the CBE material and/or in conducting the CBE program.

Not involved

Field-tested computer materials

Yes

No

Settings

Type of program

Adult basic education -- Purpose of the course was to improve basic skills in arithmetic, reading, or writing.

Technical training--Purpose of the course was to provide training in specific applied skills, e.g., aviation, auto repair, etc.

Subject ability level

Low

Average or mixed

High

Publication history

Year of the report

Before 1969

1970 - 1974

1975 - 1979

1980 - 1984

Source of study

Technical report -- Clearinghouse document, paper presented at a convention, etc.

Dissertation

Professional publication -- Journal article, scholarly book, etc.

Table 2

Major Features and Achievement Effect Sizes (ES) in 23 Studies of Computer-Based Education

Study	Place	Time	Educational intent	Computer use	Weeks of instruction	Achievement ES
Aaron, Call, & Muench (1975)	Georgia	1974	ABE	Managing	15	0.70
Attia, Miller, & Kitz (1975)	Massachusetts	1972-1973	TT	Simulation	1	1.53
Buckley & Rauch (1979)	New York	1978-1979	ABE	Tutoring	36	0.64
Carson, Graham, Harding, Johnson, Mayo, & Salop (1975)	Tennessee	1973	TT	Managing	3	1.28
Crawford & Crawford (1978)	North Island, New Zealand	1974-1975	TT	Tutoring	1	1.08
Dallman, DeLeo, Main, & Gilliman (1977)						
Study I	Texas	1975	TT	Tutoring	8	0.02
Study II	Texas	1975	TT	Tutoring	--	0.78
Deignan & Duncan (1978)	Texas	1978	TT	Tutoring	1	1.08
Evans, Skiles, & Harris (1979)	California	1979	TT	Managing	2	0.18
Fairweather & Diem (1978)	Texas	1977	ABE	Tutoring	8	0.50
Ford, Slough, & Hurlock (1972)	California	1971	TT	Tutoring	--	0.42
Fredericks & Hoover-Rice (1977)	California	1974-1975	TT	Drill and practice	1	-0.23
Geller & Shugoll (1983)	Virginia	1981-1982	ABE	Tutoring	9	0.18

Table 2 (continued)

Study	Place	Time	Educational intent	Computer use	Weeks of instruction	Achievement ES
General Electric Ordnance Systems (1975)	Virginia	1975	TT	Tutoring	1	0.35
Hirata (1973)	Georgia	1975	TT	Tutoring	23	0.18
Longo (1976)	New Jersey	1972	TT	Tutoring	4	0.06
Meyer, Dry, & Hinckley (1983)	Illinois	1981-1982	ABE	Tutoring	12	0.16
Ozarowski (1973)	New York	1971	TT	Tutoring	6	0.58
Scanland (1970)	Florida	1968	TT	Tutoring	6	-0.20
Schwartz & Haskell (1966)	New York	1964-1965	TT	Tutoring	2	0.54
Schwartz & Long (1967)	New York	1965	TT	Tutoring	6	-0.68
Stern (1975)	California	1973-1975	TT	Tutoring	6	-0.18
Trollip (1979)	Illinois	1976	TT	Simulation	1	0.73

Note. Dash indicates that information was not provided in the research report. ABE = adult basic education; TT = technical training.

Table 3

Means and Standard Errors of Effect Sizes (ES)

For 23 Studies Classified by Study Features

Study feature	Number of comparisons	Effect sizes M	SE
Use of computer			
CAI	18	0.29	0.11
CMI	3	0.72	0.32
CEI	2	1.13	0.40
Duration of instruction			
Less than 9 weeks	15	0.45	0.16
More than 9 weeks	5	0.37	0.12
Author of program			
Locally developed	16	0.37	0.15
Commercially developed	7	0.54	0.12
Type of interaction			
Off-line	2	0.99	0.29
Terminal with main frame	21	0.37	0.11
Microcomputer	0	--	--
Subject assignment			
Nonrandom	12	0.30	0.16
Random	11	0.26	0.15
Instructors			
Different	17	0.46	0.12
Same	5	0.28	0.34

Table 3 (continued)

Study feature	Number of comparisons	Effect sizes M	SE
Time of instruction			
Different semester	3	0.29	0.65
Same semester	20	0.44	0.10
Instruction method for Control group			
Lecture	14	0.38	0.12
Individualized instruction	9	0.48	0.22
Source of test			
Combined local and commercial	15	0.45	0.16
Commercial only	8	0.37	0.11
Test scoring bias			
Objective	23	0.42	0.11
Nonobjective	0	--	--
Evaluator involvement			
Involved	17	0.34	0.10
Not involved	6	0.65	0.32
Field-tested material			
No	4	0.45	0.45
Yes	19	0.42	0.10
Type of program			
Adult basic education	5	0.44	0.11
Technical training	18	0.42	0.14

Table 3 (continued)

Study feature	Number of comparisons	Effect sizes M	SE
Learner ability			
Low	4	0.20	0.19
Average and high	18	0.50	0.13
Nature of publication			
Unpublished	13	0.27	0.12
Dissertation	2	0.38	0.20
Published	8	0.69	0.23
Year of Publication			
1966-1969	2	-0.07	0.61
1970-1974	4	0.25	0.17
1975-1979	14	0.60	0.15
1980-1983	3	0.17	0.01

Table 4

Effects of CBE on Instructional Time

Study	Ratio of time (X/C)
Aaron, Call & Muench (1975)	0.86
Carson, Graham, Harding, Johnson, Mayo, & Salop (1975)	0.33
Crawford & Crawford (1978)	0.44
Dallman, DeLeo, Main, & Giliman (1977)	0.97
Deignan & Duncan (1978)	0.87
Evans, Skiles, & Harris (1979)	0.65
Ford, Slough, & Hurlock (1972)	0.52
Fredericks & Hoover-Rice (1977)	0.16
General Electric Ordnance Systems (1975)	1.14
Longo (1976)	0.64
Ozarowski (1973)	0.89
Schwartz & Haskell (1966)	0.89
Schwartz & Long (1967)	0.85